

**AFRL-RX-TY-TP-2008-4507**

**POSTPRINT**



# **TRANSPORTABLE WASTE-TO-ENERGY SYSTEM (TWES) ENERGY RECOVERY FROM BARE BASE WASTE**

**Mikel L. Sawyer**

**Applied Research Associates  
P.O. Box 40128  
Tyndall Air Force Base, FL 32403**

**FEBRUARY 2008**

**Distribution Statement A:  
Approved for public release; distribution unlimited.**

**This work was presented at the Air Force Agile Combat Support Modernization Planning Conference (ACS 2007) in Tampa FL, 29 Nov 2007.**


**AIRBASE TECHNOLOGIES DIVISION  
MATERIALS AND MANUFACTURING DIRECTORATE  
AIR FORCE RESEARCH LABORATORY  
AIR FORCE MATERIEL COMMAND  
139 BARNES DRIVE, SUITE 2  
TYNDALL AIR FORCE BASE, FL 32403-5323**

<b>REPORT DOCUMENTATION PAGE</b>					<i>Form Approved OMB No. 0704-0188</i>	
<small>The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.</small>						
<b>PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.</b>						
<b>1. REPORT DATE (DD-MM-YYYY)</b>		<b>2. REPORT TYPE</b>			<b>3. DATES COVERED (From - To)</b>	
<b>4. TITLE AND SUBTITLE</b>				<b>5a. CONTRACT NUMBER</b>		
				<b>5b. GRANT NUMBER</b>		
				<b>5c. PROGRAM ELEMENT NUMBER</b>		
<b>6. AUTHOR(S)</b>				<b>5d. PROJECT NUMBER</b>		
				<b>5e. TASK NUMBER</b>		
				<b>5f. WORK UNIT NUMBER</b>		
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b>					<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>	
<b>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b>					<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b>	
					<b>11. SPONSOR/MONITOR'S REPORT NUMBER(S)</b>	
<b>12. DISTRIBUTION/AVAILABILITY STATEMENT</b>						
<b>13. SUPPLEMENTARY NOTES</b>						
<b>14. ABSTRACT</b>						
<b>15. SUBJECT TERMS</b>						
<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT</b>	<b>18. NUMBER OF PAGES</b>	<b>19a. NAME OF RESPONSIBLE PERSON</b>	
a. REPORT	b. ABSTRACT	c. THIS PAGE			<b>19b. TELEPHONE NUMBER (Include area code)</b>	




This presentation and its entire documents or portions of it may be presented or distributed as necessary for advancing project goals.

In the future, the content may be updated for accuracy and clarity.



# Transportable Waste-to-Energy Sys.





### Objectives & Technologies

- Novel design → initial prototype testing indicates low pollution emissions
- Refine design to insure stable, long-term operation and minimize power requirements
- Characterize & incorporate system to shred bulk waste
- Air-transportable size & weight

### Description

A furnace to combust shredded solid waste at domestic & deployed bases: Currently, trash such as wood, paper, plastic, tires, etc. are removed and/or partially burned. Instead the furnace, coupled with a shredder, will completely burn the waste and provide heat for water or other needs.

### Payoff

- Reduce trash removal requirements at deployed military bases – Improved security
- Convert trash to heat at home & abroad to heat water for heating, showers, cleaning equipment; absorption A/C
- Potential for cleaning UXO with direct heat or steam
- Potential for neutralizing chem/bio weapons

2

IMAGE: “Furn Trailer Painted 2007\_2.JPG”



- Trash *OR* Fuel!

- Shipping materials: pallets, plastic wrap, foam pellets, cardboard boxes, etc.
- Worn-out supplies: clothing, tents, wooden or plastic building materials
- Daily trash: disposable dishes, water bottles, MRE containers, old documents,
- Maintenance waste streams: dirty fuel, oil, liquid solvents.



solid waste production in Balkins

Combustable Waste 5,620 lb/soldier/year  
US Army CERL, "Base Camp Solid Waste Characterization Study"

Airmen	1,100	airmen
Daily Production	16,924	lb/day
	705	lb/hr




## Bare-Base Need for TWES




- Foreign vendors transport the trash  
→ Manual inspections of garbage trucks
- Or, US personnel haul to external dump site → risk injury of scavengers
- Or, partial, smoky burning on-site.

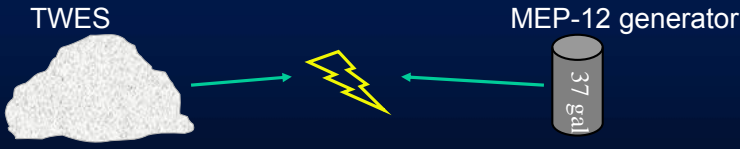




## Predicted Benefit of TWES



- For 1,100 airmen
  - 700 lb/hr solid waste produced by base
  - 20% efficiency [(Net Electricity Gen.)/(Heat Value of Waste Material)]
  - Net electricity 205 kW
  - Corresponds to 13 gal/hr in a 38% efficient MEP-12 diesel generator
- Per 1 ton of Solid Waste



1 ton solid waste → 586 kW-hr electricity ← 37 gallons diesel fuel

5

### Heating Value

- Municipal Solid Waste      11,620 kJ/kg = 5,000 Btu/lb    (Curlee and Das, 1991, chp4, p.181, pdf p.34)
- No. 2 Fuel Oil                      45,263 kJ/kg



- Many County Governments sponsor Waste-to-Energy recycling facilities.
  - W-to-E is simplified way to get most value from unwanted trash
  - Recycling requires greater sorting and additional energy input



Bay County, Florida



Miami-Dade County, Florida





## *Deployable Furnace System Bare-Base Application*



- Potential Uses of Heat

- Heat water for showers, laundry, dishes
- Heat facilities
- Steam clean equip., engines
- Produce electricity; Absorption cooling



Water heater fueled by JP-8





## TWES Fuel Processing



Bulk Trash



Shredded Fuel



Shredder



TWES Furnace



## *Furnace System for TWES*



- Furnace "FURN" has been built and tested.



9

IMAGE: "Furn Trailer Painted 2007\_2.JPG"



*Deployable Furnace System Design*

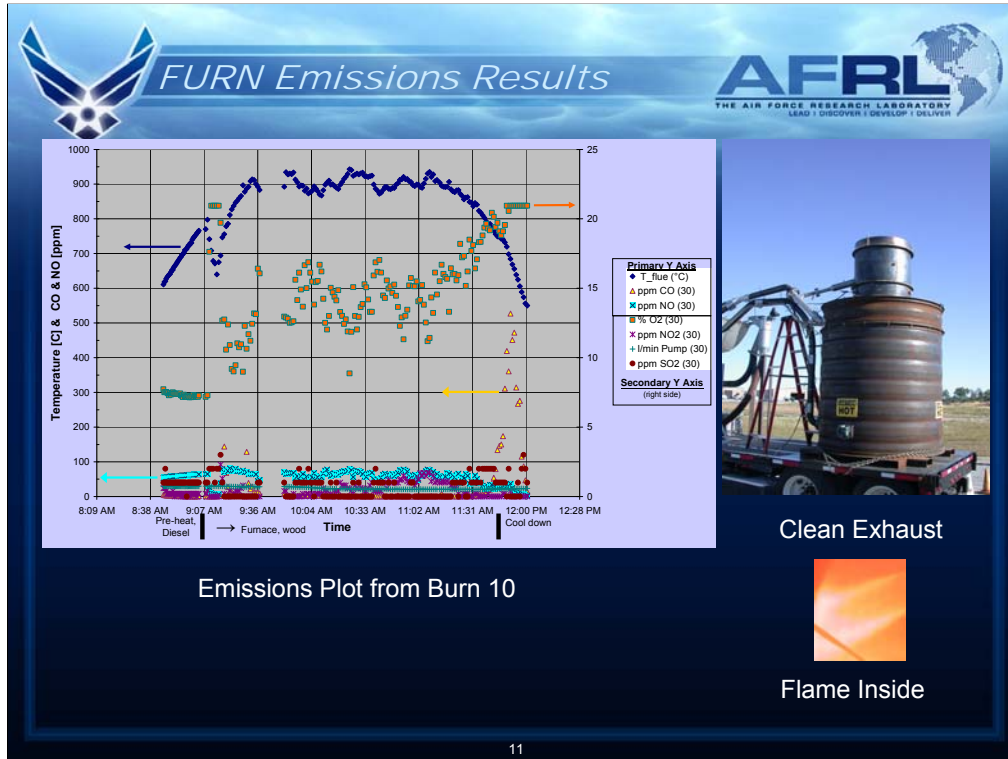
**AFRL**  
THE AIR FORCE RESEARCH LABORATORY  
LEAD | DISCOVER | DEVELOP | DELIVER

Target Operating Conditions

Feed rate	100 to 500 lb/hr = 45 to 227 kg/hr
Heat Content	± 11,620 kJ/kg
Material bulk density	5 to 8 lb/ft <sup>3</sup> , 80 to 130 gm/Liter
Volumetric flow of solids	20 to 100 ft <sup>3</sup> /hr = 9.5 to 47 L/min (based on 5 lb/ft <sup>3</sup> )
Particle size	3/8" in all dimensions and smaller, including dust
Total Airflow	145 to 730 SCFM, = up to 20,696 SLPM, to match the feed rates.

10

- Municipal Solid Waste      11,620 kJ/kg = 5,000 Btu/lb (Curlee and Das, 1991, chp4, p.181, pdf p.34)

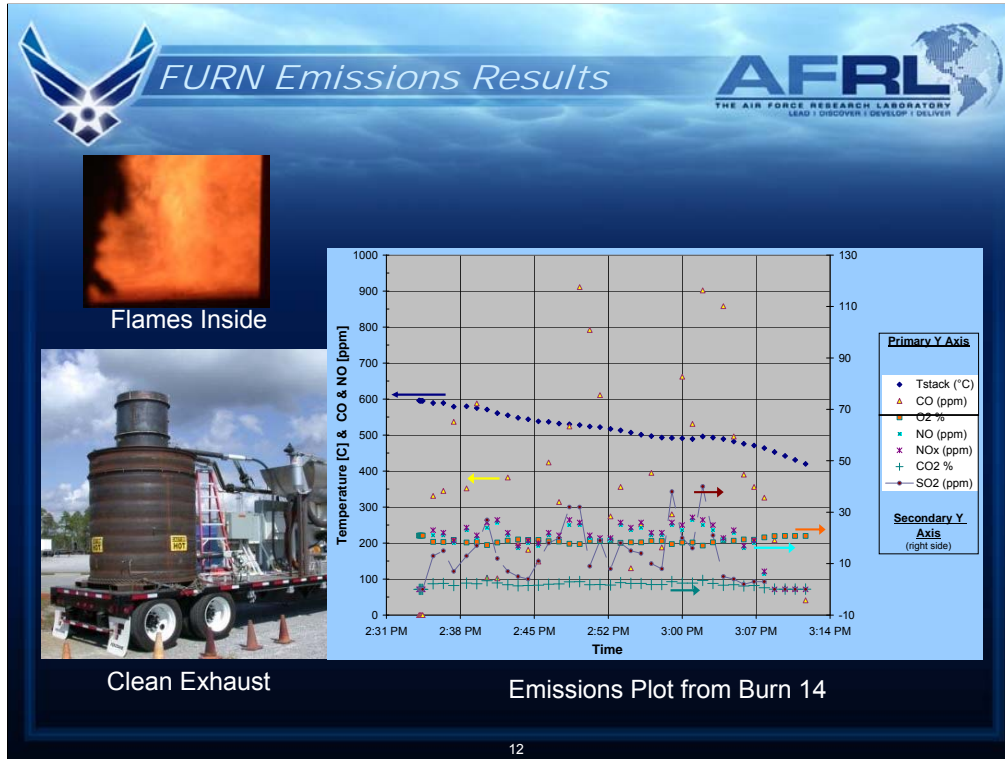


Graph from Burn 10 (~ 10:00AM)

Emissions limits from EPA and/or FDEP may be added later.

IMAGES: (1) Burn 07 outside, clean exhaust: "small\_ Furn Burn07 3\_37PM Outside and invisible exh.JPG"

(2) Burn 13, inside bright flame "cropped\_ Furn Burn 13 02\_55PM 1.JPG"

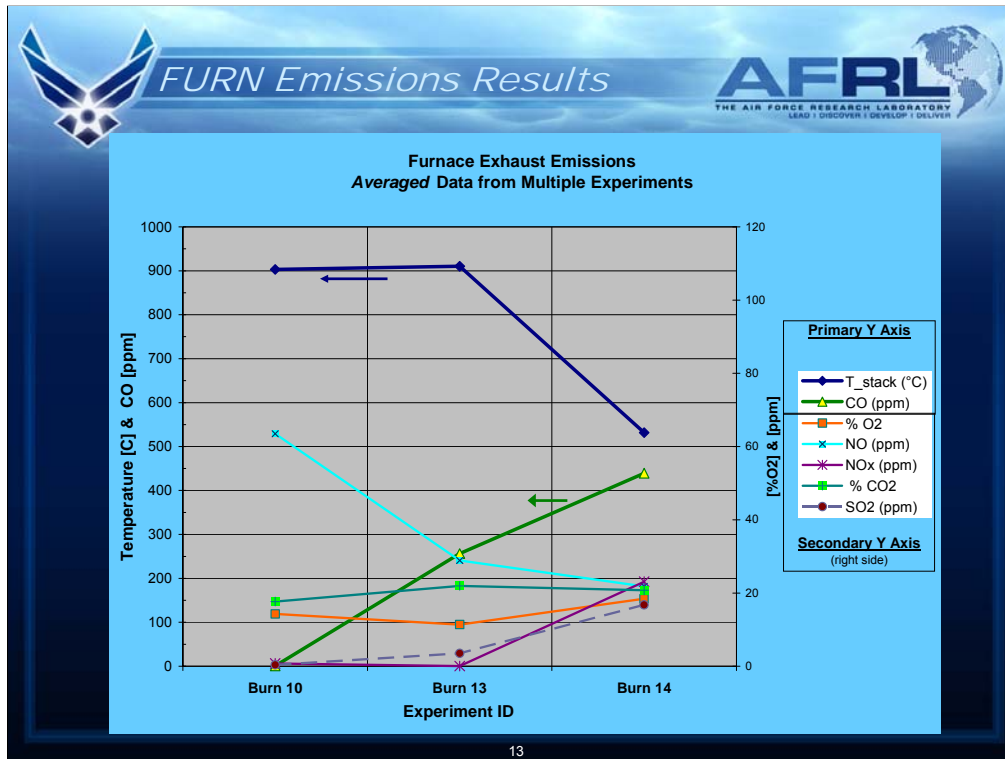


Graph from Burn 14

Emissions limits from EPA and/or FDEP may be added later.

IMAGES: (1) Burn 13 inside furnace: “small\_ Furn Burn 13 02\_27PM 2.JPG”

(2) Burn 08 outside, most of trailer, clean exhaust “small\_ Burn08 12\_06pm furn trailer clean exhaust.JPG”



Averaged emissions results from Burn 10, Burn 13, and Burn 14. Averaging usually occurred over a period of 20 to 35 minutes.

Emissions limits from EPA and/or FDEP may be added later.



## Converting FURN to TWES



- Next, add steam generator, steam turbine, and electric generator
- Have funding from DOE Federal Energy Management Program (FEMP) to initiate the conversion.

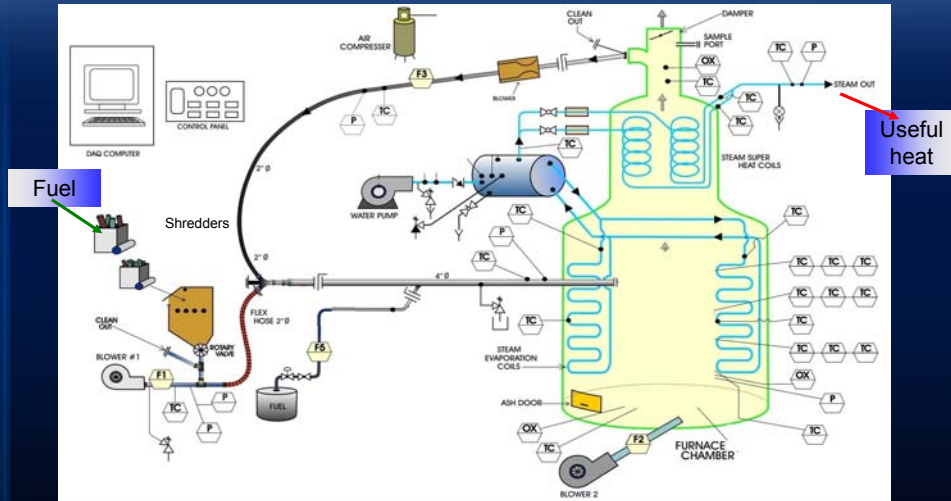



- Will install and test electricity production at Tyndall AFB







## TWES Process Diagram





TWES Research @ Tyndall AFB





**Dr. Mikel Sawyer**  
contractor with ARA, Inc.  
Air Force Research Lab, Airbase Tech. Div. (AFRL/RXQ)  
(850) 283-3725; [Mike.Sawyer.ctr@tyndall.af.mil](mailto:Mike.Sawyer.ctr@tyndall.af.mil)

Sunrise at Tyndall AFB

16

IMAGE “small\_ Furn Burn 02\_001 sunrise.JPG”